METHOD AND SYSTEM FOR MULTIDIMENTIONAL DATABASE MANAGEMENT

5   ## Field of the Invention

The current invention is generally related to multidimensional database management, and more particularly related to processing multidimensional data without layer structure information.

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BACKGROUND OF THE INVENTION

A multidimensional database model contains data corresponding to a point having values in multidimensional space that is defined by a plurality of dimensions. The multidimensional database model is generally effective in analyzing the data in a

15   multifaceted manner. Based upon a predetermined rule, it is a basic function to correspond a value of data that corresponds to one or more of points in the multidimensional space to other values corresponding to other points. For example, the above basic function is disclosed in "OLAP Practical Data Warehouse," Toyoshima and Kimura, pp76-79, (1997);

20   "OLAP Solutions Building Multidimensional Information Systems," Thomsen, pp. 89-104, (1997). The above described basic function is useful in constructing a database with minimally necessary data input as well as in retrieving data that has been already calculated.

25   In a multidimensional database model, the multidimensional space as defined by a plurality of dimensions is called "cube." The dimensions in the cube is generally expressed by a set of members that have a layer structure. A point in the multidimensional space as defined by an arbitrary member at each dimension is named "cell," and a value of the data corresponding to the cell is "a cell value." For example, using multidimensional

30   data that represents sales units and sales amounts of products sold by a company A in

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Japan, the cube includes a time dimension, a retail store dimension, a merchandise
dimension and a unit dimension.

5   To illustrate the above related example, FIGURE 20 is a diagram for describing
conventional layer structure information storing layer information on members for each
dimension. A layer 4301 for the time dimension has "1999" as the highest member or the
highest member in the layer structure, and the highest member 1999 in turn has two child
members, 1999Q1 and 1999Q2. Similarly, the child member 1999Q1 has grand child
members, 199901, 199902 and 199903. By the same token, the other child member
10   1999Q2 has grand child members, 199904 and 199905. The grand children members,
199901, 199902, 199903, 199904 and 199905 do not have any great grand children and are
defined as the lowest members in the above example. The level is accordingly assigned to
the members based upon a position in the layer. The lowest members are situated at Level
0 while the direct parent of the lowest members is located at Level 1. Similarly, the direct
15   parent of Level 1 members are located at Level 2. The highest members are located at the
level that is equal to the number of layers minus one.

Still referring to FIGURE 20, a layer 4302 for a retail store dimension has all the
sales territories or nation wide territories as the highest member. The highest member has
20   two child members including Eastern Japan and Western Japan. Eastern Japan further
owns two child members including Chiba store and Saitama store. Western Japan further
owns two child members including Osaka store and Hiroshima store. Similarly, a layer
4303 for a merchandise dimension has the all merchandises as the highest member. The
highest member has two child members including home appliance and audiovisual
25   equipment (AV). Home Appliance further owns two child members including washers and
refrigerators. AV further owns two child members including television sets and video
equipment. Lastly, a layer 4304 in a unit dimension has two members including a number
of sales and an amount of sales but, the members in the unit dimension have no layer
structure.

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Now referring to FIGURE 21, a diagram illustrates an example of conventional layer structure definition data. The conventional layer structure definition data 3201 through 3204 respectively define the time dimension, the retail store dimension, the merchandise dimension and the unit dimension, and each of the conventional layer structure definition data 3201 through 3204 contains a plurality of records that are separated by lines. Each of the records has members that are separated by commas, and the separation format is called comma separated value format (CSV). One record potentially includes all the members from the highest member to the lowest member. The conventional layer structure definition data 3201 through 3203 each is organized to list records according to the level. That is, in the above example, a record at Level 2 is followed by a record at Level 1 and then by a record at Level 0. For the layer structure definition data 3204, a record has only members at Level 0.

Now referring to FIGURE 22, a diagram illustrates an example of conventional data. The data 3301 is stored in the cube and in the above described CSV format. Each of the record includes members and corresponding cell values. In the example, each record thus contains five fields respectively for information on month/year, a retail store, a merchandise name, a number of sales and an amount of sales. The first three fields are respectively from the time dimension, the retail store dimension and the merchandise dimension. On the other hand, the last two fields are cell values representing the number of sales and the amount of sales from the unit dimension.

FIGURE 23 is a diagram illustrating an exemplary display of multidimensional data. The exemplary display is a screen multidimensional data analysis on a terminal device. The horizontal axis includes members on the time dimension while the vertical axis includes members on the retail store dimension. All members from the above dimensions are displayed. On the other hand, as shown in the upper right corner of the display, only one member such as television is displayed in the merchandise dimension and only one member such as sales amount is displayed in the unit dimension. The above exemplary screen display shows the sales amount for televisions at each retail store for

each quarter. For example, the data representing the member 1999Q1 for the time

dimension is a total value of the data 199901, 199902 and 199903. Similarly, the data

representing the member, Eastern Japan for the time dimension is a total value of the data

Chiba store and Saitama store. According to the previously noted dimensional layer

5   structure, the data is a total value. One of the basic functions of the multidimensional

database management system is to search the total value. To obtain more detailed data,

other basic functions include a drill down function for changing a currently displayed

member to its child member or a drill up function for conversely changing the currently

displayed member to its parent member.

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          In order to respond to a search request for a total value at a high speed, other

multidimensional database functions store previously calculated total values on an as-

necessary basis. For example, Japanese Patent Publication Hei 9-265479 discloses

techniques to search and summarize multidimensional data at a high speed. Another

15   example, Japanese Patent Publication Hei 11-22461 discloses storage and search

techniques for data having discontinuous members in a multidimensional database. There

are relatively frequent needs to store in a multidimensional database some member data

that is not included in the current layer and then to analyze the data. Using the example of

sales data, the above described data includes a new store to be opened and a new product to

20   be sold, and the new data is to be included in the multidimensional data. To analyze sales

data for the new products such as books and music CDs that have new titles almost on a

daily basis, the multidimensional data layer needs to be updated at a high frequency.

          Now referring to FIGURE 24, a diagram illustrates conventional exemplary data

25   that includes members that are not registered in the layer structure information. For

example, a first field of a first record is a member 3311 that has a value of "199906." The

member 3311 is unregistered in the time dimensional layer 4301 as shown in FIGURE 20.

Similarly, a second field of a second record is a member 3312 that has a value of

"Yokohama Store." The member 3312 is unregistered in the retail store dimensional layer

30   4302 as shown in FIGURE 20. Lastly, a third field of a third record is a member 3313 that

has a value of "refrigerator." The member 3313 is unregistered in the merchandise

dimensional layer 4303 as shown in FIGURE 20. In general, there are two ways to

process the above described unregistered member data. The first way is to regard the

unregistered member data to be invalid, and its corresponding record that contains the

5   unregistered member data is also regarded as being invalid. The second way is to regard

the unregistered member data to be new.

        The above two options are further related to the database operations. The first

processing option terminates the data handling operation upon detecting a record

10   containing any unregistered member data. Alternatively, the data handling operation skips

the record to a next one according to the first processing option. The data handling

operation terminates by issuing an alarm signal, and the unregistered member remains to

be unregistered at the layer information. Of course, the corresponding record is not

included in the database and remains excluded from analysis. On the other hand, the above

15   second processing option registers the currently unregistered member. In registering the

new member, there are two ways to find a new position in the layer. One position is

created at a new location as a new member without having any relation to the existing

members.

20   Now referring to FIGURE 25, a diagram illustrates layer structure information for

conventional data that includes members that are not previously registered in the layer

structure information. The layer 4305 indicates that an unregistered member, "Yokohama

store" is now registered as an independent member 4306 in the layer information structure

4305. The above described processing allows the incorporation of the unregistered

25   member 4306 into the layer of the multidimensional database. Despite the incorporation of

the previously unregistered member 4306, during an analysis stage, since the newly

incorporated member 4306 is isolated from other members, the isolated member 4306 is

not reflected in the summary. Furthermore, since the isolated member 4306 cannot be

reached by a drill up function or a drill down function, the isolated member 4306 is not

30   included in any analysis. In other words, the above described isolated position is mere

temporary until the newly added member 4306 is officially and functionally incorporated into the layer structure information.

5   The second processing option avoids the above described difficulty by providing a predetermined parent member for orphan members or unregistered members and assigning the unregistered members to the predetermined parent member. In layer 4307, the predetermined parent member 4308 is "others," and the previously unregistered member 4309 is "personal computers." The newly incorporated member 4309 is now linked under the predetermined parent member 4308 in this example. Because of the

10   linkage between the members 4308 and 4309, the newly incorporated member 4309 is now included in an analysis of the layer 4307. The newly incorporated member 4309 is also reached from other members by drilling up or down. Despite the above described improvement, since the layer generally does not have a layer structure that a user may expect, the analysis often lead to unexpected results. Although Japanese Patent Publication

15   Hei 11-102368 discloses a technique to determine a group or member name based upon a character pattern of the unregistered member, the disclosed technique is silent on adding a new group in the existing layer information.

SUMMARY OF THE INVENTION

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In order to solve the above and other problems, according to a first aspect of the current invention, a system for maintaining a multidimensional database, including: an input unit for inputting a member; a dimensional layer information unit for storing dimensional layer information, the dimensional layer information including layer structure

25   information to represent layer structure of members in the multidimensional database and a layer rule for defining rules to generate the layer structure information; and a dimensional layer information management unit connected to the input unit and the dimensional layer information unit for managing the dimensional layer information, the dimensional layer information management unit determining whether or not corresponding information has been registered for the member in the layer structure information, the dimensional layer

30   been registered for the member in the layer structure information, the dimensional layer

information management unit generating the corresponding layer information according to the layer rule in the absence of the corresponding information and registering the corresponding layer information in the layer structure information.

5   These and various other advantages and features of novelty which characterize the invention are pointed out with particularity in the claims annexed hereto and forming a part hereof. However, for a better understanding of the invention, its advantages, and the objects obtained by its use, reference should be made to the drawings which form a further part hereof, and to the accompanying descriptive matter, in which there is illustrated and 10   described a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

          FIGURE 1 is a diagram illustrating a preferred embodiment of the 15   multidimensional database processing system according to the current invention.

          FIGURE 2 is a flow chart illustrating steps involved in a preferred process of the system control unit 11 according to the current invention.

20   FIGURE 3 is a flow chart illustrating steps involved in a preferred process of the layer rule definition process according to the current invention.

          FIGURE 4 is a flow chart illustrating steps involved in a preferred process of the multidimensional data storage process according to the current invention.

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          FIGURE 5 is a flow chart illustrating steps involved in a preferred process of the multidimensional data analysis process according to the current invention.

          FIGURE 6 is a flow chart illustrating steps involved in a preferred process of the 30   layer structure information search process according to the current invention.

FIGURE 7 is a flow chart illustrating steps involved in a preferred process of the layer structure information updating process according to the current invention.

5   FIGURE 8 illustrates exemplary layer rule definition data for the time dimension as used in a preferred embodiment according to the current invention.

FIGURE 9 is a diagram illustrating exemplary layer structure definition data for unregistered members as used in a preferred embodiment according to the current

10   invention.

FIGURE 10 is a diagram illustrating an example of the layer structure information after a modification by a preferred embodiment according to the current invention.

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FIGURE 11 is a diagram illustrating a portion of exemplary retail store dimensional layer rule definition in a preferred embodiment according to the current invention.

20   FIGURE 12 is a diagram illustrating a portion of exemplary data of a CSV-formatted file that is used in a preferred embodiment according to the current invention.

FIGURE 13 is a flow chart illustrating steps involved in a second preferred process of the layer structure information updating process according to the current

25   invention.

FIGURE 14 is a diagram illustrating the preferred embodiment of the multidimensional database system according to the current invention.

FIGURE 15 is a diagram illustrating a portion of merchandise dimensional layer rule definition data that is used in the third preferred embodiment according to the current invention.

5   FIGURE 16 is a diagram illustrating an exemplary RDB product master table for the RDB that is used in the third preferred embodiment according to the current invention.

FIGURE 17 is a flow chart illustrating steps involved in a third preferred process of the layer structure information updating process according to the current invention.

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FIGURE 18 is a diagram illustrating exemplary layer structures respectively for the three dimensions that are to be used with the fourth preferred embodiment according to the current invention.

15   FIGURE 19 is a diagram illustrating changes in the layer information or the layer structure as the fourth preferred process is performed according to the current invention.

FIGURE 20 is a diagram for describing conventional layer structure information storing layer information on members for each dimension.

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FIGURE 21 is a diagram illustrating an example of conventional layer structure definition data.

FIGURE 22 is a diagram illustrating an example of conventional data.

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FIGURE 23 is a diagram illustrating an exemplary display of multidimensional data.

FIGURE 24 is a diagram illustrating conventional exemplary data that includes

30   members that are not registered in the layer structure information.

FIGURE 25 is a diagram illustrating layer structure information for conventional data that includes members that are not previously registered in the layer structure information.

FIGURE 26 is a diagram illustrating a portion of retail store dimensional layer rule definition data that is used in the fifth preferred embodiment according to the current invention.

FIGURE 27 is a diagram illustrates a portion of data that is to be stored in the multidimensional database in the fifth preferred embodiment according to the current invention.

FIGURE 28 is a flow chart illustrating steps involved in a fifth preferred process of the layer structure information updating process according to the current invention.

FIGURE 29 illustrates that the change from the retail store dimension layer 4302 as shown in FIGURE 20 to the final retail store dimension layer 4330.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

Referring now to the drawings, wherein like reference numerals designate corresponding structures throughout the views, and referring in particular to FIGURE 1, a diagram illustrates a preferred embodiment of the multidimensional database processing system according to the current invention. The multidimensional database processing system includes a computer system 1 that includes a central processing unit (CPU) 2, a main memory unit 3, a secondary or external memory unit 4 such as magnetic disks and a plurality of terminals 6 that are connected by a network 5. A multidimensional database management unit 10 includes a system control unit 11, a multidimensional data

management unit 12, a dimensional layer information management unit 13, a layer rule
management unit 14, a layer structure information management unit 15 and a layer
structure information update unit 16. The multidimensional database management unit 10
exists in the main memory unit 3 and includes the system control unit 11, the
5   multidimensional data management unit 12 and the dimensional layer information
management unit 13. The system control unit 11 controls the system in general. In
particular, the system control 11 receives a layer rule definition request 21, a
multidimensional data storage request 22 and a multidimensional data analysis request 23
and sends the requests 21, 22 and 23 to the multidimensional data management unit 12 and
10   the dimensional layer information management unit 13. The system control 11
subsequently sends the processed results back to the requested terminals 6. The
multidimensional data management unit 12 generally manages a multidimensional
database 44 in an external or secondary memory unit 4. The multidimensional data
management unit 12 has a first function to read storage data 33 and to store it in the
15   multidimensional database 44, a second function to search in the multidimensional
database 44 and to return the multidimensional data as well as a third function to return the
data that is specified for an analysis by the search range in the multidimensional database
44.

20   Still referring to FIGURE 1, the dimensional layer information management unit
13 further includes the layer rule management unit 14, the layer structure information
management unit 15 and the layer structure information update unit 16. The dimensional
layer information management unit 13 manages dimensional layer information that exists
in the externally located secondary memory unit 4. The layer rule management unit 14
25   manages layer rule 42 that is used in generating layer information for a member. The layer
rule management unit 14 has functions to read layer structure rule definition data 31, to
register at the layer rule 42 and to obtain the layer rule 42. The layer structure information
management unit 15 manages layer structure information 43 for registering members in a
dimension. The layer structure information management unit 15 has functions to read the
30   layer structure definition data 32, to search layer structure information 43 and to obtain the

layer rule 42 if layer information on the specified member is not registered at the layer

structure information 43. The layer structure information management unit 15 further

inputs the layer rule 42 and the above specified member and instructs the layer structure

information update unit 16 to generate the layer information. The layer structure

5   information management unit 15 returns the generated information to the above requested

unit. In response to a request to generate the layer information for the above specified

member from the layer structure information management unit 15, the layer structure

information update unit 16 stores the generated layer structure information at the layer

structure information 43 according to the layer rule 42 and returns the generated layer

10   structure information to the layer structure information management unit 15.

        Computer programs function as the multidimensional database management unit

10, the system control unit 11, the multidimensional data management unit 12, the

dimensional layer information management unit 13, the layer rule management unit 14, the

15   layer structure information management unit 15 and the layer structure information update

unit 16 in the computer system 1. The above computer programs are stored in recording

media such as CD-ROM and magnetic disks and are loaded in memory before execution.

The recording media include media other than CD-ROM.

20   Now referring to FIGURE 2, a flow chart illustrates steps involved in a preferred

process of the system control unit 11 according to the current invention. The system

control unit 11 receives request inputs from the user via the terminal 6 in a system control

process 110. In general, the inputted requests are sequentially grouped into separate

groups. In a step 111, it is determined whether or not the inputted requests are layer rule

25   definition requests. If it is, a layer rule definition process is read in and performed in a step

50. On the other hand, if it is determined that the inputted requests are not layer rule

definition requests in the step 111, it is further determined whether or not the inputted

requests are multidimensional data storage requests in a step 112. If it is, a

multidimensional data storage process is read in and performed in a step 60. On the other

30   hand, if it is determined that the inputted requests are not multidimensional data storage

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requests in the step 112, lastly it is determined whether or not the inputted requests are multidimensional data analysis requests in a step 113. If it is, a multidimensional data analysis process is read in and performed in a step 70 and the preferred process terminates. Otherwise, the preferred process also terminates.

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Now referring to FIGURE 3, a flow chart illustrates steps involved in a preferred process of the layer rule definition process 50 according to the current invention. In a step 501, the layer rule management unit 14 reads from the terminal 6 the specified layer structure rule definition data 31. In a step 502, the layer rule management unit 14 stores the specified layer structure rule definition data 31 in the external memory unit 4. When the specified layer structure rule definition data 31 as shown in FIGURE 8 is inputted, the inputted data 31 is registered in the layer rule 42. The registered layer rule 42 is later used when the data includes an unregistered member.

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Now referring to FIGURE 4, a flow chart illustrates steps involved in a preferred process of the multidimensional data storage process 60 according to the current invention. In a step 601, the multidimensional data management unit 12 reads one record of the data 33 that is specified by an input from the terminal unit 6. In a step 602, a member on one dimension is separated from the above record. The separated member from the step 602 is inputted into a layer structure information search process 80 so that the corresponding layer information is obtained. In a step 603, it is determined whether or not a member of every dimension is processed. If not every dimension has been processed, the preferred process returns to the step 602. On the other hand, if every dimension has been processed, in a step 604, a cell value is obtained from the cell value field in the record. In a step 605, the layer information from the step 80 and the cell value from the step 604 are combined to provide multidimensional data to be stored in the multidimensional database 44. Lastly, it is determined whether or not every record is processed in a step 606. If every record is processed, the preferred process terminates. On the other hand, if any record remains unprocessed, the preferred process returns to the step 601 to repeat the above described process.

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Now referring to FIGURE 5, a flow chart illustrates steps involved in a preferred process of the multidimensional data analysis process 70 according to the current invention. In a step 701, an analysis range is inputted from the user via the terminal unit 6, and the multidimensional data management unit 12 performs an analysis within the specified range. As a result of the analysis, a member is obtained for the above dimension. In a step 80, the searching layer structure information process is called in for the member from the step 701 to obtain the corresponding layer information. In a step 702, it is determined whether or not every dimension is processed. If not every dimension has been processed, the preferred process returns to the step 701 to repeat the above described steps. On the other hand, if every dimension has been processed, in a step 703, the multidimensional database 44 is searched according to the layer information that is obtained in the step 80. Lastly, in a step 704, the search results from the step 703 are returned to the user via the terminal unit 6.

Now referring to FIGURE 6, a flow chart illustrates steps involved in a preferred process of the layer structure information search process 80 according to the current invention. The layer structure information search process 80 is called in from the multidimensional data storage process 60 and the multidimensional data analysis process 70. In a step 801, the layer structure information management unit 15 refers to the layer structure information 43 and searches for the layer information of the specified member that is inputted via the terminal unit 6. In a step 802, it is determined whether or not the searched layer information has been registered. If the searched layer information exists, the preferred process proceeds to a step 803 where the searched layer information is returned. On the other hand, if the searched layer information is not registered or does not exist, the preferred process obtains the layer rule 42 in a step 804 and calls a layer structure information updating process 90 with the obtained layer rule 42 and the specified member before proceeding to the step 803. In the layer structure information updating process 90, the layer information is generated for the specified member, and the layer structure information 43 is updated before the generated layer information is returned to the layer

structure information management unit 15. Finally, in a step 803, the layer structure
information management unit 15 returns the received layer information to an original
calling unit. The preferred process then terminates. The above described steps 802, 804
and 90 are the most characteristic processing according to the current invention. These
5   steps enable to generate layer information according to the layer rule 42 even in response
to an inquiry by an unregistered member. Since the layer structure information 43 is
updated, no additional command is necessary for modifying the layer structure prior to or
subsequent to a multidimensional data storage request.

10   Now referring to FIGURE 7, a flow chart illustrates steps involved in a preferred
process of the layer structure information updating process 90 according to the current
invention. The layer rule 42 and the above specified member from the layer structure
information management unit 15 are inputted to the layer structure information updating
process 90. In a step 901, the layer structure information update unit 16 receives an
15   instruction for layer information generation for the above specified member and examines
the layer rule 42. If the layer information is not to be generated from the member name,
the preferred process terminates. On the other hand, if the layer information is to be
generated from the member name, the layer structure information update unit 16 branches
to a step 902. In the step 902, layer structure definition data is generated as the layer
20   information by performing character row conversion according to the layer rule 42. Based
upon the layer structure definition data, after the layer information of the above specified
member is registered at the layer structure information 43, the above generated layer
information is returned to the layer structure information management unit 15. The
preferred process then terminates.

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FIGURE 8 illustrates exemplary layer rule definition data for the time dimension
as used in a preferred embodiment according to the current invention. The layer rule
definition data 3110 includes comments that are specified by a preceding pound sign, "#"
on the first two lines as well as substantive information for generating other information.
30   The third line indicates that the layer information is to be generated from the member

name. In general, the following lines including the fourth line respectively indicate a generation method for each member at LEVEL 0, LEVEL 1 and LEVEL 2. In particular, the fourth line indicates that the member name is used without altering at the lowest member or LEVEL 0. The fifth line through the tenth line indicate the generation method for LEVEL 0. The sixth line through the ninth line specify replacement or conversion rules based on formal expressions. A new member name at LEVEL 2 is obtained by applying a character row conversion as expressed by the formal expressions to an input member name. For example, the formal expression on the seventh line is used to describe the above character row conversion process. If the fifth and sixth characters in the character row are "04", "05" or "06," a character row, "Q2" replaces them after the first or fourth character of the input member to obtain the character row conversion output. Assuming that an input member name is "199906," the LEVEL 1 member name becomes "1999Q2." The eleventh and thirteenth lines indicate that a row of the first through fourth characters is used without modification as a LEVEL 2 member name. For example, if an input member name is "199906," "1999" becomes the LEVEL 2 member name.

Now referring to FIGURE 9, a diagram illustrates exemplary layer structure definition data for unregistered members as used in a preferred embodiment according to the current invention. The exemplary layer structure definition data is generated for storing data 3310 including unregistered data of FIGURE 24. When the layer information is generated for the unregistered member 3311 of FIGURE 24 based upon the layer rule definition data 3110 as shown in FIGURE 8, the layer structure definition data 3211 is generated as layer information. Layer rule definition data for generating the layer structure definition data 3212 or 3212 will be described later.

FIGURE 10 is a diagram illustrating an example of the layer structure information 43 after being modified by a preferred embodiment according to the current invention. Layers 4311 through 4313 show the layer structure information 43 after the layer information of the unregistered members 3311 through 3313 of FIGURE 24 is registered using the layer structure definition data 3211 through 3213 of FIGURE 9. For

example, the layer 4301 as shown in FIGURE 20 is registered at the layer structure information 43 of FIGURE 1 and the layer rule definition data 3110 as illustrated in FIGURE 8 is registered in the layer rule 42 of FIGURE 1. When the member 3311 of the first record in the layer rule definition data 3110 is to be stored in the multidimensional

5   database 44 of FIGURE 1, it is detected that the member 3311 is unregistered. Upon the detection, the layer rule definition data 3110 is used to generate the layer structure definition data 3211 as shown in FIGURE 9 for the above unregistered member, and the newly generated layer structure definition data 3211 is stored at the layer structure information 43. As a result, the time dimensional layer 4301 as shown in FIGURE 20

10   changes to the time dimensional layer 4311 as shown in FIGURE 10. As described above, the preferred embodiment according to the current invention generates the layer information for a specified member by converting a character row of a member name according to a predetermined formal expression. As illustrated in the example of the time dimension, the member name information is efficiently generated according to a

15   predetermined rule and is stored at the layer structure information. Since the layer rule determines the layer information generation, the multidimensional database improves the management efficiency.

A second preferred embodiment of the multidimensional database system

20   according to the current invention generates the layer information for an unregistered member based upon information obtained from the CSV formatted file. The second preferred embodiment generally relies upon a file name to recognize a file containing relevant layer information and expressions such as CSV format in the recognized file. After accessing the above described information from a file, the second preferred embodiment

25   utilizes the layer rule 42 which specifies to generate the layer information and to store it at the layer structure information 43. One example of the layer rule 42 is retail store dimensional layer rule definition data. Based upon the layer information obtained according to a specified format from a file specified in the layer rule 42, the layer information is generated for an unregistered member and is stored at the layer structure

30   information 43. In general, the above process for the second preferred embodiment is

substantially identical to that of the first preferred embodiment except for the layer structure information update process 90A as shown in FIGURE 13.

Now referring to FIGURE 11, a diagram illustrates a portion of exemplary retail store dimensional layer rule definition in a preferred embodiment according to the current invention. The exemplary layer rule 42 includes the layer rule definition data 3120. The first two lines in the layer rule definition data 3120 are comments. The third line indicates that the layer information is to be generated from a file named "file 1" in the CSV format. The remaining three lines respectively indicate the correspondence between columns and the LEVEL 0 member, LEVEL 1 member and LEVEL 2 member.

Now referring to FIGURE 12, a diagram illustrates a portion of exemplary data 3126 of a CSV-formatted file that is used in a preferred embodiment according to the current invention. The name of the above exemplary file is "file 1" and contains member names of the retail store dimension. In combination with the description on the fourth line in the layer rule definition data 3120 of FIGURE 11, the retail store dimensional member layer information is generated. For example, given an unregistered member, "Yokohama store," the content of the file as shown in FIGURE 12 is scanned to find a third record containing the unregistered member in the third column. As specified on the fifth and sixth lines of the layer rule definition data 3120, the members that correspond to LEVEL 1 and LEVEL 2 are respectively "Eastern Japan" and "All Areas" in the CSV-formatted data 3126. When there is more than one record that satisfy the requirement, one way to continue the preferred process is to interrupt as an error according to an user input or to issue an alarm. Alternatively, a predetermined rule selects one of the satisfactory records. For example, a first satisfactory record is chosen in the CSV-formatted file.

Now referring to FIGURE 13, a flow chart illustrates steps involved in a second preferred process of the layer structure information updating process 90A according to the current invention. The layer rule 42 and the above specified member from the layer structure information management unit 15 are inputted to the layer structure information

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updating process 90A. In a step 9011, the layer structure information update unit 16 receives an instruction for layer information generation for the above specified member from the layer structure information management unit 15 and examines the layer rule 42. If the layer information is to be generated from a non-CSV-formatted file, the second

5   preferred process terminates. On the other hand, if the layer information is to be generated from the CSV-formatted file, the preferred process branches to a step 9012. In the step 9012, one record is read in from the CSV-formatted file that is specified in the layer rule 42. In a step 9013, it is determined whether or not a column that is specified in the layer rule 42 contains the matching member name in the record. If a match is found in the step

10   9013, the layer structure definition data is generated as the layer information from the specified member of the record according to the layer rule 42 in a step 9014. In the step 9014, by using the generated layer structure definition data, the layer information of the specified member is also stored in the layer structure information 43, and the above generated layer information is returned from the layer structure information management

15   unit 15. On the other hand, if there is no match, the second preferred process proceeds to a step 9015, where it is determined whether or not a file end has reached. Upon failing to reach a file end, the second preferred process goes back to the step 9012 to repeat the above steps. Upon reaching the file end, a step 9016 performs an error handling procedure such as issuing an error message. The second preferred embodiment then terminates.

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As described above, in the second preferred process, the multidimensional database improves the management efficiency. For example, the layer 4302 as shown in FIGURE 20 is registered at the layer structure information 43 of FIGURE 1 and the retail store dimension layer rule definition data 3120 as illustrated in FIGURE 11 is registered in

25   the layer rule 42 of FIGURE 1. When the member 3312 of the second record in the layer rule definition data 3120 is to be stored in the multidimensional database 44 of FIGURE 1, it is detected that the member 3312 or "Yokohama store" is unregistered. Upon the detection, the layer rule definition data 3120 is used to generate the layer structure definition data 3212 as shown in FIGURE 9 for the above unregistered member, and the

30   newly generated layer structure definition data 3212 is stored at the layer structure

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information 43. As a result, the retail store dimensional layer 4302 as shown in FIGURE

20 changes to the retail store dimensional layer 4312 as shown in FIGURE 10. As

described above, the preferred embodiment according to the current invention generates the

layer information for a specified member by using a predetermined file containing

5   sequentially placed members of each layer. As illustrated in the example of the retail store

dimension, the member name information is efficiently generated according to a

predetermined rule and is stored at the layer structure information. Since the layer rule

determines the layer information generation, the multidimensional database improves the

management efficiency.

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        A third preferred embodiment of the multidimensional database system according

to the current invention generates the layer information for an unregistered member based

upon information obtained from relational databases (RDB). The third preferred

embodiment generally relies upon information to recognize a RDB containing relevant

15   layer information and additional information on the RDB data format. After accessing the

above described information from the RDB, the third preferred embodiment utilizes the

layer rule 42 which specifies to generate the layer information and to store it at the layer

structure information 43. One example of the layer rule 42 is merchandise dimensional

layer rule definition data. Based upon the layer information obtained according to the

20   specified format in the RDB specified in the layer rule 42, the layer information is

generated for an unregistered member and is stored at the layer structure information 43.

In general, the above process for the third preferred embodiment is substantially identical

to that of the first preferred embodiment except for the layer structure information update

process 90B as shown in FIGURE 17.

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        Now referring to FIGURE 14, a diagram illustrates the third preferred

embodiment of the multidimensional database system according to the current invention.

In the third preferred embodiment, a multidimensional database management unit 10 is

connected to a RDB management system 25 and has access to a RDB 26 via a

30   predetermined set of procedures. In the third preferred embodiment, the multidimensional

database management unit 10 is further connected to the dimensional layer information unit 41 and the multidimensional database 44 as shown in the first preferred embodiment with respect to FIGURE 1. The dimensional layer information unit 41 further includes the layer rule 42 as well as the layer structure information 43.

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Now referring to FIGURE 15, a diagram illustrates a portion of merchandise dimensional layer rule definition data 3130 that is used in the third preferred embodiment according to the current invention. The exemplary layer rule 42 includes the above layer rule definition data 3130. The first two lines in the layer rule definition data 3130 are comments. The third line indicates that the layer information is to be generated from a data table named "RDB Product Master List." The fourth and fifth lines respectively indicate the correspondence of the LEVEL 0 members and LEVEL 1 members in the above specified list. The sixth line indicates that the LEVEL 2 member is "All Products" or "All Merchandise."

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Now referring to FIGURE 16, a diagram illustrates an exemplary RDB product master table for the RDB that is used in the third preferred embodiment according to the current invention. The RDB product master table stores member names on the merchandise dimension in the RDB 26. In combination with the information on the fourth and the following lines in the layer rule definition data 3130 of FIGURE 15, the layer information is generated for the merchandise dimension. For example, given an unregistered member, "PCs," the RDB 26 is searched to obtain a record 261 whose data value for the small classification is "PCs." The fourth and the fifth lines in the layer rule definition data 3130 of FIGURE 15 specify the LEVEL 1 and LEVEL 2 members that correspond to "computers" and "all merchandises."

Now referring to FIGURE 17, a flow chart illustrates steps involved in a third preferred process of the layer structure information updating process 90B according to the current invention. The layer rule 42 and the above specified member from the layer structure information management unit 15 are inputted to the layer structure information

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updating process 90B. In a step 9021, the layer structure information update unit 16

receives an instruction for layer information generation for the above specified member

from the layer structure information management unit 15 and examines the layer rule 42.

If the layer information is not to be generated from the RDB 26, the third preferred process

5   terminates. On the other hand, if the layer information is to be generated from the RDB

26, the third preferred process branches to a step 9022. In the step 9022, the RDB

management system 25 is connected based upon a predetermined procedure. In a step

9023, an inquiry is made to the RDB 26 based upon the above specified members and the

parameters that are specified in the layer rule 42. In the step 9024, the layer structure

10   definition data is generated as the layer information from the inquiry results according to

the layer rule 42. In the step 9024, by using the generated layer structure definition data,

the layer information of the specified member is also stored in the layer structure

information 43, and the above generated layer information is returned to from the layer

structure information management unit 15. The third preferred process then terminates.

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As described above, in the third preferred process, the multidimensional database

improves the management efficiency. For example, the layer 4303 as shown in FIGURE

20 is registered at the layer structure information 43 of FIGURE 1 and the retail store

dimension layer rule definition data 3130 as illustrated in FIGURE 15 is registered in the

20   layer rule 42 of FIGURE 1. When the member 3313 of the third record in the layer rule

definition data 3130 is to be stored in the multidimensional database 44 of FIGURE 1, it is

detected that the member 3313 or "PCs" is unregistered. Upon the detection, the layer rule

definition data 3130 is used to generate the layer structure definition data 3213 as shown in

FIGURE 9 for the above unregistered member, and the newly generated layer structure

25   definition data 3213 is stored at the layer structure information 43. As a result, the

merchandise dimensional layer 4302 as shown in FIGURE 20 changes to the retail store

dimensional layer 4313 as shown in FIGURE 10. As described above, the preferred

embodiment according to the current invention generates the layer information for a

specified member by using a member name placed at a specified row in a predetermined

30   RDB. As illustrated in the example of the merchandise dimension, the member name

information is efficiently generated according to a predetermined rule and is stored at the layer structure information. Since the layer rule determines the layer information generation, the multidimensional database improves the management efficiency.

5   A fourth preferred embodiment of the multidimensional database system according to the current invention generates the layer information for an unregistered member without layer structure information based upon a registered layer rule. For the lack of the layer structure information 43, the fourth preferred embodiment newly generates the layer structure information 43 for each dimension and the layer information

10   for unregistered members according to the layer rule 42. Then, the newly generated layer information is stored at the newly generated layer structure information 43. To further illustrate the fourth preferred embodiment, the example for the first preferred embodiment is used to describe that the time dimension layer 4301 as shown in FIGURE 20 is modified to the layer 4310 as shown in FIGURE 18. Similarly, the same example is used to describe

15   that the data 3310 as shown in FIGURE 24 is modified to the data 3301 as shown in FIGURE 22.

        Now referring to FIGURE 18, a diagram illustrates exemplary layer structures respectively for the three dimensions that are to be used with the fourth preferred

20   embodiment according to the current invention. In the time dimension layer 4310, no layer structure information has been registered, and the layer structure information 43 lacks the time dimension. Assuming that layer rule definition data 3110 as shown in FIGURE 8 is registered as the layer rule 42 for the time dimension, when a storage request is issued for storing the data 3301 as shown in FIGURE 22, the system control process 110 as shown in

25   FIGURE 2 sequentially transfers its control to the multidimensional data storage process 60 as shown in FIGURE 4, the layer structure information search process 80 as shown in FIGURE 6 and the layer structure information update process 90 as shown in FIGURE 7. Using the same example, when the first record of the data 3301 is stored at the multidimensional database, although the time dimension member data, "199901" is read in,

30   since the time dimension layer 4310 lacks the layer structure information 43 and the layer

information is not registered, the member is considered to be unregistered in the step 801
as shown in FIGURE 6. The fourth preferred process then proceeds to the step 804 to
obtain the layer rule definition data 3110 such as shown in FIGURE 8 as the layer rule 42.
In the layer structure information update process 90, the layer rule definition data 3110 is
5   applied to the member value, "199901" to generate the layer information via the character
row conversion.

Now referring to FIGURE 19, a diagram illustrates changes in the layer
information or the layer structure as the fourth preferred process is performed according to
10   the current invention. In the layer structure information update process 90, after the time
dimensional layer structure information 43 is newly generated, the layer information 3221
is generated by applying the layer rule definition data 3110. The layer information 3221 is
stored as a time dimensional layer 4321 at the newly generated time dimensional layer
structure information 43. As a result, the member "199901" is no longer unregistered and
15   is now treated as a registered member in the time dimensional layer 4321. Similarly, after
the first and second records of the data 3301 as shown in FIGURE 22 are stored, the third
record is processed. Since the layer structure information 43 for the time dimension is as
shown in the layer 4321, the time dimensional member, "199902" is regarded as
unregistered. For this reason, the layer structure information update process 90 generates
20   the layer information 3222 and registers the layer information 3222 as the time
dimensional layer 4322 in the information structure information 43. Furthermore, when
the fifth, sixth and seventh records of the data 3301 as shown in FIGURE 22 are processed,
the time dimensional members, "199903," "199904" and "199905" are regarded as
unregistered. For this reason, the layer structure information update process 90 generates
25   the layer information 3223, 3224 and 3225 and sequentially registers these layer
information 3222, 3224 and 3225 as the time dimensional layers 4323, 4324 and 4325 in
the information structure information 43. As described above, the fourth preferred
embodiment according to the current invention generates the layer structure information 43
if it does not exist and the layer information for a specified member according to the layer
30   rule 42. The preferred embodiment then stores the newly generated layer information at

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the newly generated layer structure information 43. Because of the above features, even

when the multidimensional database 44 is newly created, the layer member information is

automatically generated for each dimension based upon the layer rule 42 and the data to be

stored. Since the layer rule determines the layer information generation, the

5   multidimensional database improves the management efficiency.

A fifth preferred embodiment of the multidimensional database system according

to the current invention generates the layer information for an unregistered member

without layer structure information based upon a plurality of registered layer rules. The

10   fifth preferred embodiment relates one main layer rule for a dimension to more than one

sub-layer rules. The sub-layer rules have substantially the same functions as described

with respect to the first through third preferred embodiments. The main layer rule includes

information for recognizing the sub-layer rules and specifies the sequential application of

the sub-layer rules for a success. The fifth preferred embodiment will be further illustrated

15   by the example of changing the retail store dimensional layer rule definition data 3120 as

shown in FIGURE 11 to layer rule definition data 3140, 3141 and 3142 as shown in

FIGURE 26. The fifth preferred embodiment will be also further illustrated by the

example of changing the data 3310 as shown in FIGURE 24 to data 3340 as shown in

FIGURE 27.

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Now referring to FIGURE 26, a diagram illustrates a portion of retail store

dimensional layer rule definition data 3140 that is used in the fifth preferred embodiment

according to the current invention. The retail store dimension layer rule definition data is

in a main layer rule 3140. Other sub layer definition data is in sub-layer rules 3141 and

25   3142. The first two lines in the main layer rule 3140 indicate comments. A third line

indicates the application of a first sub-layer rule called "Store_Rule 1." Similarly, a fourth

line indicates the application of a second sub-layer rule called "Store_Rule 2." The

application of these sub-layer rules is sequential and follows the above order. The layer

rule definition data 3141 is substantially similar to the one as described with respect to

30   FIGURE 11 for the second preferred embodiment. The layer rule will be referred to as

"Store_Rule 1." The layer rule definition data 3142 is substantially similar to the one as described with respect to FIGURE 8 for the first preferred embodiment. The layer rule will be referred to as "Store_Rule 2."

5   Now referring to FIGURE 27, a diagram illustrates a portion of data that is to be stored in the multidimensional database 44 in the fifth preferred embodiment according to the current invention. Each record in the data 3340 has five fields. The first three fields are time dimension, retail store dimension and merchandise dimension in order. The remaining two fields are cell values for sales number and sales amount in the unit

10   dimension.

        Now referring to FIGURE 28, a flow chart illustrates steps involved in a fifth preferred process of the layer structure information updating process 90C according to the current invention. The layer rule 42 and the above specified member from the layer

15   structure information management unit 15 are inputted to the layer structure information updating process 90C. In a step 9031, the layer structure information update unit 16 receives an instruction for layer information generation for the above specified member from the layer structure information management unit 15 and determines whether or not the layer rule 42 has a plurality of rules. If the layer rule is not plural, the fifth preferred

20   process terminates. On the other hand, if the layer rule is plural, the fifth preferred process branches to a step 9032. In the step 9032, the main layer rule is read in. In a step 9033, sub-layer rules are sequentially read in from the above main layer rule that has been read in the step 9032. In the step 9034, the sub layer rules are applied. In the step 9035, it is determined whether or not the results from the step 9034 have successfully obtained the

25   layer structure information. If the results are successful in the step 9035, the fifth preferred process terminates. On the other hand, if the results are not successful in the step 9035, the fifth preferred process returns to the step 9033 to repeat the steps 9033 and 9034.

        When the retail store dimensional layer 4302 is registered in the layer structure

30   information 43 as shown in FIGURE 20, the retail store dimensional layer definition data

3140, 3141 and 3142 as shown in FIGURE 26 are registered at the layer rule 42. When the data 3340 as shown in FIGURE 27 is stored in the multidimensional database 44, a first record "Eastern Japan Sapporo Store" in the data 3340 is recognized as an unregistered member and the first sub-layer rule or the layer rule definition data 3141 of the layer rule

5   definition data 3140 is applied in a first attempt. Although the layer rule definition data 3141 instructs to read the file 1 in the CSV format, since "Eastern Japan Sapporo Store" is not found by scanning the file contents 3126 as shown in FIGURE 12, the application of the layer rule definition data 3140 fails. Subsequently, the second sub-layer rule or the layer rule definition data 3142 of the layer rule definition data 3140 is applied in a second

10   attempt. The layer rule definition data 3142 generates the layer structure information by performing the character row conversion as described with respect to the first preferred embodiment. Using the exemplary input member name of "Eastern Japan Sapporo Store," the fourth line in the layer rule definition data 3142 indicates that the name of the input member becomes the Level 0 member name. The fifth through seventh lines indicate that

15   if the second word is "Japan," the first and second words "Eastern Japan" become the Level 1 member name. The eighth through tenth lines indicate that "all sales territories" becomes the Level 2 member name without any restriction. As the result of the above described character row conversion, "all sales territories," "Eastern Japan" and "Eastern Japan Sapporo Store" have been generated as new layer information. The newly generated

20   layer information is registered in the layer structure information 43. Finally, the retail store dimension layer 4302 as shown in FIGURE 20 becomes the retail store dimension layer 4330 as shown in FIGURE 29. As described above, the fifth preferred embodiment according to the current invention generates the layer structure information 43 by subsequently applying the sub-layer rules of the main layer rule for a specified member.

25   As in the retail store dimension members, some member names are arbitrarily determined by the users while other member names are determined by a predetermined rule. In the above mixed situation, the member structure information is efficiently generated. Since the layer rule determines the layer information generation, the multidimensional database improves the management efficiency.

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It is to be understood, however, that even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only, and that although changes may be made in detail, especially in matters of shape, size and arrangement of parts, as well as implementation in software, hardware, or a combination of both, the changes are within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.